

AD-A034 025

ROME AIR DEVELOPMENT CENTER GRIFFISS AFB N Y

F/G 20/14

EFFECT OF LOCATION ON THE EFFECTIVENESS OF SPATIAL FILTERS, (U)

SEP 76 R L FANTE

RADC-TR-76-296

NL

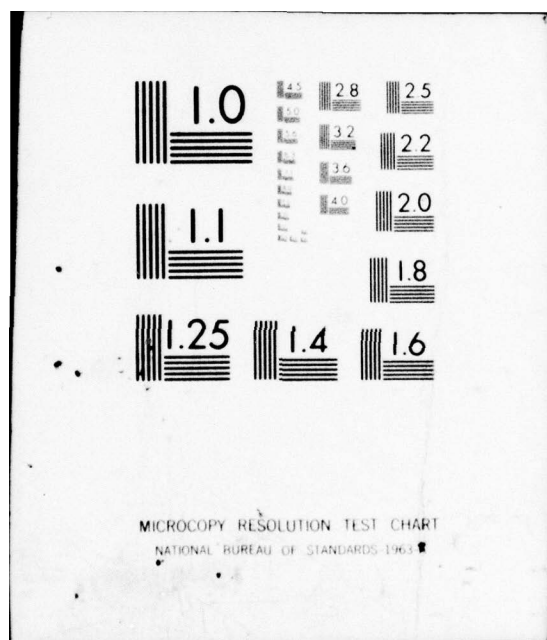
UNCLASSIFIED

1 OF 1  
AD  
A034025



END

DATE  
FILMED  
2-77



ADA034025

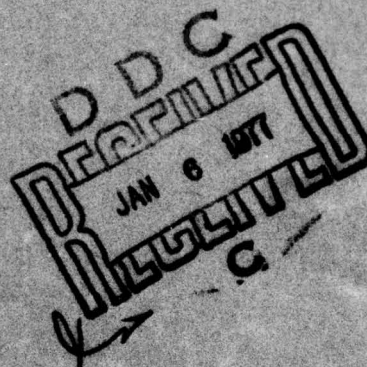
RADC-TR-76-296  
IN-HOUSE REPORT  
SEPTEMBER 1976

12



## Effect of Location on the Effectiveness of Spatial Filters

RONALD L. FANTE



Approved for public release; distribution unlimited.

ROME AIR DEVELOPMENT CENTER  
AIR FORCE SYSTEMS COMMAND  
GRIFFISS AIR FORCE BASE, NEW YORK 13441



**Title of Report:** Effect of Location on the Effectiveness of Spatial Filters

**This report has been reviewed by the RADC Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be releasable to the general public, including foreign nations.**

**This report has been reviewed and approved for publication.**

**APPROVED:**

*J. Leon Poirier*  
J. LEON POIRIER

**J. LEON POIRIER**

## Acting Chief

**Microwave Detection Techniques Br.  
Electromagnetic Sciences Division**

**APPROVED:**

Paul Schell

**ALLAN C. SCHELL**

**Acting Chief**

Electromagnetic Sciences Division

1. ☒ ☐ ☐  
 2. ☐ ☐ ☐  
 3. ☐ ☐ ☐  
 4. ☐ ☐ ☐  
 5. ☐ ☐ ☐  
 6. ☐ ☐ ☐  
 7. ☐ ☐ ☐  
 8. ☐ ☐ ☐  
 9. ☐ ☐ ☐  
 10. ☐ ☐ ☐  
 11. ☐ ☐ ☐  
 12. ☐ ☐ ☐  
 13. ☐ ☐ ☐  
 14. ☐ ☐ ☐  
 15. ☐ ☐ ☐  
 16. ☐ ☐ ☐  
 17. ☐ ☐ ☐  
 18. ☐ ☐ ☐  
 19. ☐ ☐ ☐  
 20. ☐ ☐ ☐  
 21. ☐ ☐ ☐  
 22. ☐ ☐ ☐  
 23. ☐ ☐ ☐  
 24. ☐ ☐ ☐  
 25. ☐ ☐ ☐  
 26. ☐ ☐ ☐  
 27. ☐ ☐ ☐  
 28. ☐ ☐ ☐  
 29. ☐ ☐ ☐  
 30. ☐ ☐ ☐  
 31. ☐ ☐ ☐  
 32. ☐ ☐ ☐  
 33. ☐ ☐ ☐  
 34. ☐ ☐ ☐  
 35. ☐ ☐ ☐  
 36. ☐ ☐ ☐  
 37. ☐ ☐ ☐  
 38. ☐ ☐ ☐  
 39. ☐ ☐ ☐  
 40. ☐ ☐ ☐  
 41. ☐ ☐ ☐  
 42. ☐ ☐ ☐  
 43. ☐ ☐ ☐  
 44. ☐ ☐ ☐  
 45. ☐ ☐ ☐  
 46. ☐ ☐ ☐  
 47. ☐ ☐ ☐  
 48. ☐ ☐ ☐  
 49. ☐ ☐ ☐  
 50. ☐ ☐ ☐  
 51. ☐ ☐ ☐  
 52. ☐ ☐ ☐  
 53. ☐ ☐ ☐  
 54. ☐ ☐ ☐  
 55. ☐ ☐ ☐  
 56. ☐ ☐ ☐  
 57. ☐ ☐ ☐  
 58. ☐ ☐ ☐  
 59. ☐ ☐ ☐  
 60. ☐ ☐ ☐  
 61. ☐ ☐ ☐  
 62. ☐ ☐ ☐  
 63. ☐ ☐ ☐  
 64. ☐ ☐ ☐  
 65. ☐ ☐ ☐  
 66. ☐ ☐ ☐  
 67. ☐ ☐ ☐  
 68. ☐ ☐ ☐  
 69. ☐ ☐ ☐  
 70. ☐ ☐ ☐  
 71. ☐ ☐ ☐  
 72. ☐ ☐ ☐  
 73. ☐ ☐ ☐  
 74. ☐ ☐ ☐  
 75. ☐ ☐ ☐  
 76. ☐ ☐ ☐  
 77. ☐ ☐ ☐  
 78. ☐ ☐ ☐  
 79. ☐ ☐ ☐  
 80. ☐ ☐ ☐  
 81. ☐ ☐ ☐  
 82. ☐ ☐ ☐  
 83. ☐ ☐ ☐  
 84. ☐ ☐ ☐  
 85. ☐ ☐ ☐  
 86. ☐ ☐ ☐  
 87. ☐ ☐ ☐  
 88. ☐ ☐ ☐  
 89. ☐ ☐ ☐  
 90. ☐ ☐ ☐  
 91. ☐ ☐ ☐  
 92. ☐ ☐ ☐  
 93. ☐ ☐ ☐  
 94. ☐ ☐ ☐  
 95. ☐ ☐ ☐  
 96. ☐ ☐ ☐  
 97. ☐ ☐ ☐  
 98. ☐ ☐ ☐  
 99. ☐ ☐ ☐  
 100. ☐ ☐ ☐  
 101. ☐ ☐ ☐  
 102. ☐ ☐ ☐  
 103. ☐ ☐ ☐  
 104. ☐ ☐ ☐  
 105. ☐ ☐ ☐  
 106. ☐ ☐ ☐  
 107. ☐ ☐ ☐  
 108. ☐ ☐ ☐  
 109. ☐ ☐ ☐  
 110. ☐ ☐ ☐  
 111. ☐ ☐ ☐  
 112. ☐ ☐ ☐  
 113. ☐ ☐ ☐  
 114. ☐ ☐ ☐  
 115. ☐ ☐ ☐  
 116. ☐ ☐ ☐  
 117. ☐ ☐ ☐  
 118. ☐ ☐ ☐  
 119. ☐ ☐ ☐  
 120. ☐ ☐ ☐  
 121. ☐ ☐ ☐  
 122. ☐ ☐ ☐  
 123. ☐ ☐ ☐  
 124. ☐ ☐ ☐  
 125. ☐ ☐ ☐  
 126. ☐ ☐ ☐  
 127. ☐ ☐ ☐  
 128. ☐ ☐ ☐  
 129. ☐ ☐ ☐  
 130. ☐ ☐ ☐  
 131. ☐ ☐ ☐  
 132. ☐ ☐ ☐  
 133. ☐ ☐ ☐  
 134. ☐ ☐ ☐  
 135. ☐ ☐ ☐  
 136. ☐ ☐ ☐  
 137. ☐ ☐ ☐  
 138. ☐ ☐ ☐  
 139. ☐ ☐ ☐  
 140. ☐ ☐ ☐  
 141. ☐ ☐ ☐  
 142. ☐ ☐ ☐  
 143. ☐ ☐ ☐  
 144. ☐ ☐ ☐  
 145. ☐ ☐ ☐  
 146. ☐ ☐ ☐  
 147. ☐ ☐ ☐  
 148. ☐ ☐ ☐  
 149. ☐ ☐ ☐  
 150. ☐ ☐ ☐  
 151. ☐ ☐ ☐  
 152. ☐ ☐ ☐  
 153. ☐ ☐ ☐  
 154. ☐ ☐ ☐  
 155. ☐ ☐ ☐  
 156. ☐

**FOR THE COMMANDER**

ER John P. Huss

## Plans Office



# **MISSION** *of* **Rome Air Development Center**

**RADC plans and conducts research, exploratory and advanced development programs in command, control, and communications (C<sup>3</sup>) activities, and in the C<sup>3</sup> areas of information sciences and intelligence. The principal technical mission areas are communications, electromagnetic guidance and control, surveillance of ground and aerospace objects, intelligence data collection and handling, information system technology, ionospheric propagation, solid state sciences, microwave physics and electronic reliability, maintainability and compatibility.**



**Printed by  
United States Air Force  
Hanscom AFB, Mass. 01731**

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER <b>14</b> RADC-TR-76-296	2. GOVT ACCESSION NO.	3. REPORTING DATA OF NUMBER
4. TITLE <b>6</b> EFFECT OF LOCATION ON THE EFFECTIVENESS OF SPATIAL FILTERS,		5. TYPE OF REPORT & PERIOD COVERED In-House
7. AUTHOR(s) <b>10</b> Ronald L. Fante		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Deputy for Electronic Technology (RADC/ETEP) Hanscom AFB Massachusetts 01731		10. PROGRAM ELEMENT PROJECT, TASK & REPORT NUMBER 62702F 21530201
11. CONTROLLING OFFICE NAME AND ADDRESS Deputy for Electronic Technology (RADC/ETEP) Hanscom AFB Massachusetts 01731		12. REPORT DATE <b>10</b> Sep 1976
13. CONTROLLING OFFICE NAME & ADDRESS (if different from Controlling Office) <b>16</b> 21531 <b>17</b> 021 3021		14. SECURITY CLASS. (of this report) Unclassified
15. DECLASSIFICATION/DOWNGRADING SCHEDULE		
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Antennas Spatial filters Radiation		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) We have demonstrated that the radiation pattern modification caused by the placement of either a multiple-dielectric-layer or a wire-grade spatial filter between an antenna and observer is independent of where the filter is placed, provided the filter is not located too close to the antenna to cause a significant change in antenna current distribution.		

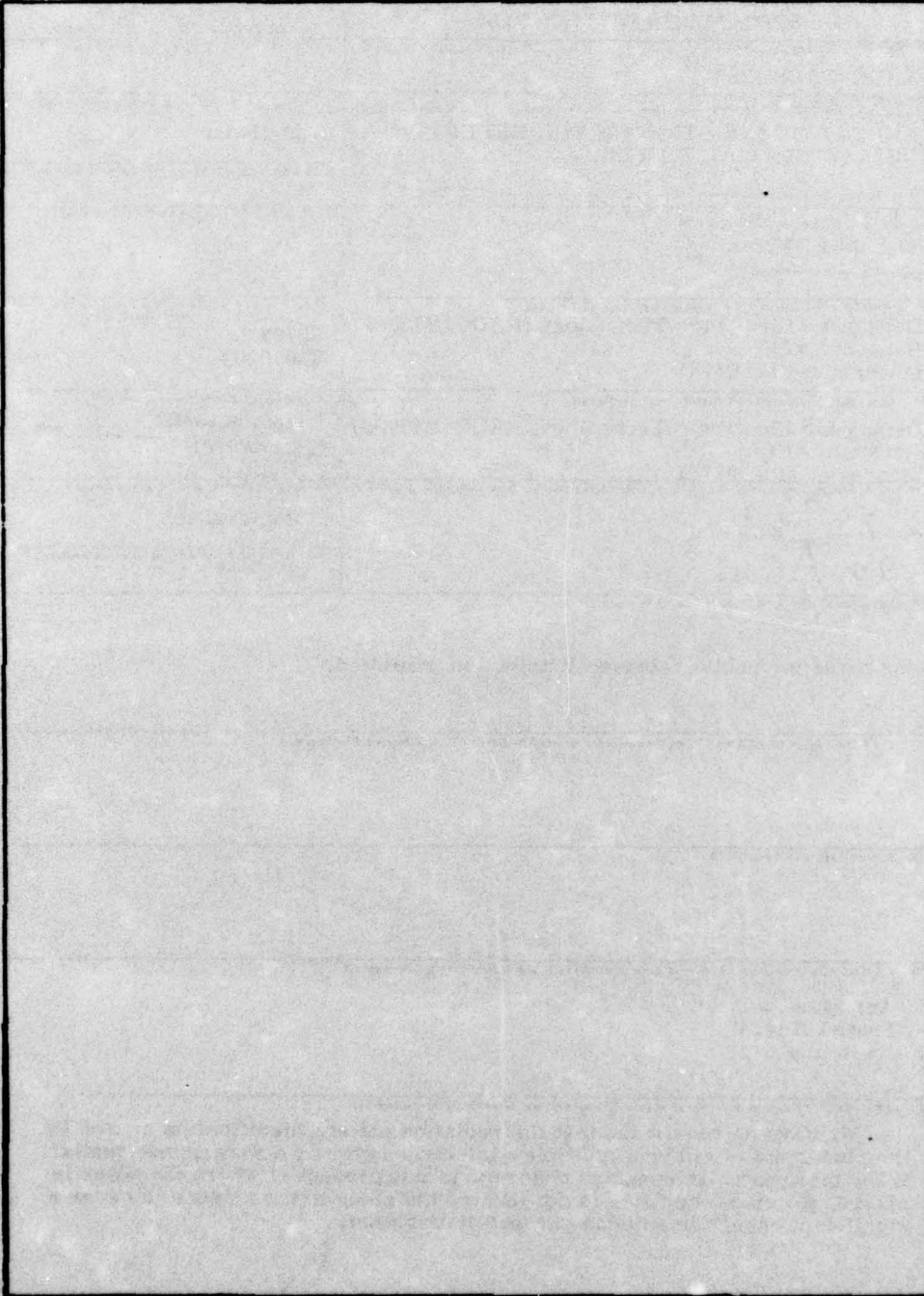
DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified  
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

309 050



SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)



SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)



## Contents

1. INTRODUCTION	5
2. REPRESENTATION OF THE SOURCE	6
3. DIELECTRIC LAYER FILTER	8
4. WIRE-GRID FILTER	9
5. DISCUSSION	13
REFERENCES	15

## Illustrations

1. Geometry Assumed	7
2. Wire-Grid Orientation	9
3. Alpha-Beta Space	11

## Effect of Location on the Effectiveness of Spatial Filters

### 1. INTRODUCTION

It has been demonstrated previously by Mailloux<sup>1</sup> that spatial filters can be useful in eliminating unwanted sidelobes in antenna arrays. These spatial filters may be composed either of multiple plane dielectric layers or wire grids. The analysis performed by Mailloux assumed that the spatial filter was located in the Fraunhofer zone of the source. We will show that the aforementioned results are also valid if the spatial filter is located in the Fresnel zone of the source antenna, provided the spatial filter is not too close to modify the source current distribution.\*

Our analysis will be based on decomposing the electromagnetic field of an arbitrary source into an ensemble of propagating and evanescent plane waves, and then seeing how each of these waves is affected by the spatial filter. We will assume that the source field is specified either over the source antenna surface or over a virtual plane just in front of the source.

---

(Received for publication 29 September 1976)

\*This is equivalent to stating that multiple scatter is ignored. That is, we assume that any wave reflected by the spatial filter is not scattered by the antenna and reradiated.

1. Mailloux, R. (1976) Synthesis of spatial filters with Chebyshev characteristics, IEEE Trans. Ant. and Prop. AP-24:174-181.



## 2. REPRESENTATION OF THE SOURCE

Let us consider a source in the plane  $z = -\Delta$ , as indicated in Figure 1. The electric field of this source, assuming time dependence  $\exp(-i\omega t)$ , in the region  $z \geq -\Delta$  can be represented quite generally as

$$\underline{E}(x, y, z) = \left(\frac{1}{2\pi}\right)^2 \iint_{-\infty}^{\infty} d\alpha d\beta \underline{\hat{E}}(\alpha, \beta) \exp[ik(\alpha x + \beta y + hz)] \quad (1)$$

where  $h = (1 - \alpha^2 - \beta^2)^{1/2} = i(\alpha^2 + \beta^2 - 1)^{1/2}$ , and  $k = 2\pi/\lambda$  where  $\lambda$  is the signal wavelength. It can be shown<sup>2</sup> that  $\underline{\hat{E}}$  can be written in the general form

$$\underline{\hat{E}}(\alpha, \beta) = \hat{x} A_x(\alpha, \beta) + \hat{y} A_y(\alpha, \beta) + \hat{z} \left[ \frac{\alpha A_x + \beta A_y}{h} \right] \quad (2)$$

where  $\hat{x}$ ,  $\hat{y}$  and  $\hat{z}$  are unit vectors. From Eq. (2) we see that once the  $x$  and  $y$  components of  $\underline{\hat{E}}$  are specified, the  $z$  component automatically follows. The complete magnetic field is also automatically specified once  $A_x$  and  $A_y$  are known.

Now suppose the transverse electric field in the plane  $z = -\Delta$  is specified to be the vector function  $\underline{f}(x, y) = \hat{x} f_x(x, y) + \hat{y} f_y(x, y)$ . Then the vector  $\underline{A}(\alpha, \beta) = \hat{x} A_x(\alpha, \beta) + \hat{y} A_y(\alpha, \beta)$  is readily found via

$$\begin{aligned} \underline{A}(\alpha, \beta) &= k^2 e^{ikh\Delta} \iint_{-\infty}^{\infty} dx dy \underline{f}(x, y) \exp[-ik(\alpha x + \beta y)] \\ &= e^{ikh\Delta} \underline{A}_0(\alpha, \beta) \end{aligned} \quad (3)$$

where  $\underline{A}_0(\alpha, \beta)$  is the wavenumber spectrum of the transverse electric field which would be obtained if the source were located at  $z = 0$ , rather than at  $z = -\Delta$ . By using Eq. (3) in (2), we easily see that

$$\underline{\hat{E}}(\alpha, \beta) = \exp(ikh\Delta) \underline{\hat{E}}_0(\alpha, \beta) \quad (4)$$

where  $\underline{\hat{E}}_0(\alpha, \beta)$  is the wavenumber spectrum of the complete electric field in the case when the source is located at  $z = 0$ , rather than at  $z = -\Delta$ .

2. Fante, R., and Mayhan, J. (1970) Bounds on the electric field outside a radiating system, IEEE Trans. Ant. and Prop. AP-18:64-68.



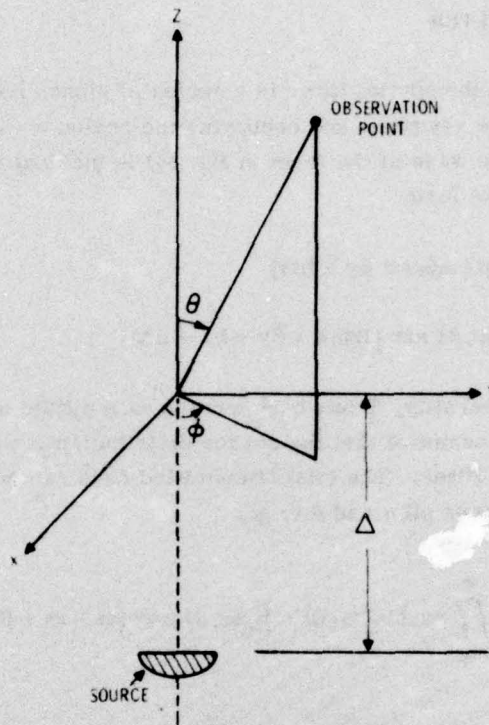


Figure 1. Geometry Assumed

Equation (1) represents the decomposition of the electric field into plane waves of the form

$$\underline{E}(\alpha, \beta) \exp [ik(\alpha x + \beta y + hz)] \quad (5)$$

When  $\alpha^2 + \beta^2 \leq 1$  these waves are propagating, whereas when  $\alpha^2 + \beta^2 > 1$  they are evanescent. We can now investigate how each of these waves is transmitted by a spatial filter located in the plane  $z = 0$ . We shall first consider the simple and obvious case of a filter consisting of multiple plane dielectric layers. We will later consider the more complex case when the filter is a wire grid.

### 3. DIELECTRIC LAYER FILTER

For the case when the spatial filter is a series of plane, homogeneous dielectric\* layers lying in the x-y plane and occupying the region  $z = 0$  to  $z = d$ , it is readily shown<sup>3</sup> that if a wave of the form in Eq. (5) is incident upon this layer, the transmitted field has the form

$$\begin{aligned} \underline{T}(\alpha, \beta) \cdot \underline{\hat{E}}(\alpha, \beta) \exp [ik(\alpha x + \beta y + hz)] \\ = \underline{T}(\alpha, \beta) \cdot \underline{\hat{E}}_0(\alpha, \beta) \exp [ik(\alpha x + \beta y + hz + h\Delta)] \end{aligned} \quad (6)$$

where for complete generality,  $\underline{T}$  has been written as a dyadic quantity. In deriving Eq. (6) it has been assumed that the source distribution is unaffected by the presence of the spatial filter. The total transmitted field can be obtained from Eq. (6) by integrating over all  $\alpha$  and  $\beta$  to get

$$\underline{E}(x, y, z) = \left(\frac{1}{2\pi}\right)^2 \iint_{-\infty}^{\infty} d\alpha d\beta \underline{T}(\alpha, \beta) \cdot \underline{\hat{E}}_0(\alpha, \beta) \exp (ik [\alpha x + \beta y + h(z + \Delta)]) \quad (7)$$

In the far field ( $z \rightarrow \infty$ ) it is easily shown that<sup>2</sup>

$$\underline{E}(x, y, z \rightarrow \infty) = \frac{K \cos \theta}{R} \underline{T}(\alpha_0, \beta_0) \cdot \underline{\hat{E}}_0(\alpha_0, \beta_0) \exp [ik(R + \Delta \cos \theta)] \quad (8)$$

where  $K$  is a constant,  $\alpha_0 = \sin \theta \cos \phi$ ,  $\beta_0 = \sin \theta \sin \phi$ ,  $R = (x^2 + y^2 + z^2)^{1/2}$  and  $\theta$  and  $\phi$  are shown on Figure 1. If the source were at  $z = 0$  instead of at  $z = -\Delta$ , the far field would be

$$\underline{E}(x, y, z \rightarrow \infty) = \frac{K}{R} \cos \theta \underline{T}(\alpha_0, \beta_0) \cdot \underline{\hat{E}}_0(\alpha_0, \beta_0) \exp(ikR) \quad (9)$$

Upon comparing Eqs. (8) and (9) we see that, in the Fraunhofer zone, the only effect of the distance  $\Delta$  between the source and the spatial filter is the introduction of the phase factor  $\exp(ik\Delta \cos \theta)$ , which is of no consequence. The reason that this result is so simple is because the evanescent modes in the source play no role in the far field. We shall see in the next section that this is no longer the case for a wire-grid filter.

\* It is assumed that each layer is homogeneous and infinite in the x-y direction. The filter is, of course, not necessarily homogeneous in the z-direction.

3. Stratton, J. (1941) Electromagnetic Theory, Chapter 9, McGraw-Hill, New York.



## 1. WIRE-GRID FILTER

A rectangular grid of metal wires can also be used as a spatial filter. Consider the wire grid shown in Figure 2, and let us suppose that this lies in the  $z = 0$  plane, with the source again located in the plane  $z = -\Delta$ . We will also assume that the wire separations,  $a$  and  $b$ , are much smaller than the signal wavelength  $\lambda$ . It can readily be shown<sup>4</sup> that, if a wave of the form given in Eq. (5) is incident upon this grid, the transmitted field in the region  $z > 0$  has the general form

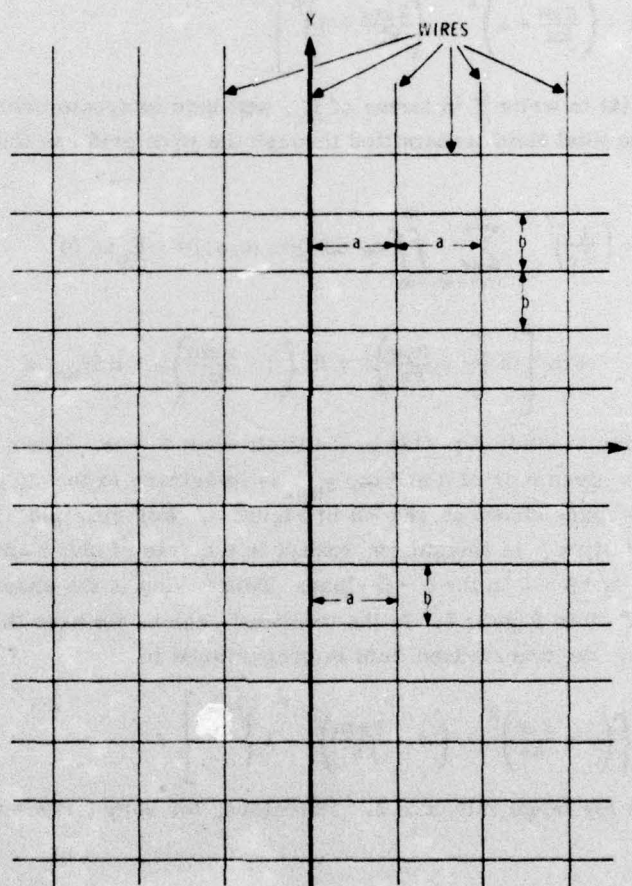


Figure 2. Wire-Grid Orientation

4. Hill, D., and Wait, J. (1976) Electromagnetic scattering of an arbitrary plane wave by a wire mesh with bonded junctions, Canadian J. Phys. 54:353-361.



$$\sum_{n, m=-\infty}^{\infty} \underline{Q}(n, m, \alpha, \beta) \cdot \hat{\underline{E}}(\alpha, \beta) \exp \left\{ ik \left[ \left( \alpha + \frac{2\pi n}{ka} \right) x + \left( \beta + \frac{2\pi m}{kb} \right) y + \gamma_{nm} z \right] \right\} \quad (11)$$

where  $\underline{Q}$  is a general dyadic quantity which depends on  $n$ ,  $m$ ,  $a$ ,  $b$ ,  $\alpha$ ,  $\beta$ , and  $k$ , but not on  $\Delta$ , and

$$\gamma_{nm} = \left[ 1 - \left( \frac{2\pi n}{ka} + \alpha \right)^2 - \left( \frac{2\pi m}{kb} + \beta \right)^2 \right]^{1/2}. \quad (12)$$

If we use Eq. (4) to write  $\hat{\underline{E}}$  in terms of  $\hat{\underline{E}}_0$ , and then integrate over all  $\alpha$  and  $\beta$ , we find that the total field transmitted through the wire grid has the form

$$\underline{E}(x, y, z) = \left( \frac{1}{2\pi} \right)^2 \sum_{n, m=-\infty}^{\infty} \iint_{-\infty}^{\infty} d\alpha d\beta \underline{Q}(n, m, \alpha, \beta) \cdot \hat{\underline{E}}_0(\alpha, \beta) \cdot \exp \left[ ik \left( \alpha + \frac{2\pi n}{ka} \right) x + ik \left( \beta + \frac{2\pi m}{kb} \right) y + ik(\gamma_{nm} z + h\Delta) \right]. \quad (12)$$

We now wish to study Eq. (12) in the limit when  $z \rightarrow \infty$ . From Eq. (11) it is clear that for a given pair of  $n$  and  $m$ ,  $\gamma_{nm}$  is imaginary except in the appropriate region in  $\alpha - \beta$  space shown as shaded in Figure 3. For example, for  $n = 1$  and  $m = 0$  the quantity  $\gamma_{00}$  is imaginary, except in a circle of unit radius centered about  $\alpha = -\lambda/a$  and  $\beta = 0$  in the  $\alpha - \beta$  plane. This region is the shaded circle denoted by  $n = 1$  and  $m = 0$  in Figure 3. In the unshaded regions we have that, for a given pair of  $n$  and  $m$ , the transmitted field is proportional to

$$\exp \left[ -kz \left\{ \left( \alpha + \frac{2\pi n}{ka} \right)^2 + \left( \beta + \frac{2\pi m}{kb} \right)^2 - 1 \right\}^{1/2} \right] \quad (13)$$

which vanishes for large values of  $z$ . Therefore, for very large  $z$  we may rewrite Eq. (12) as

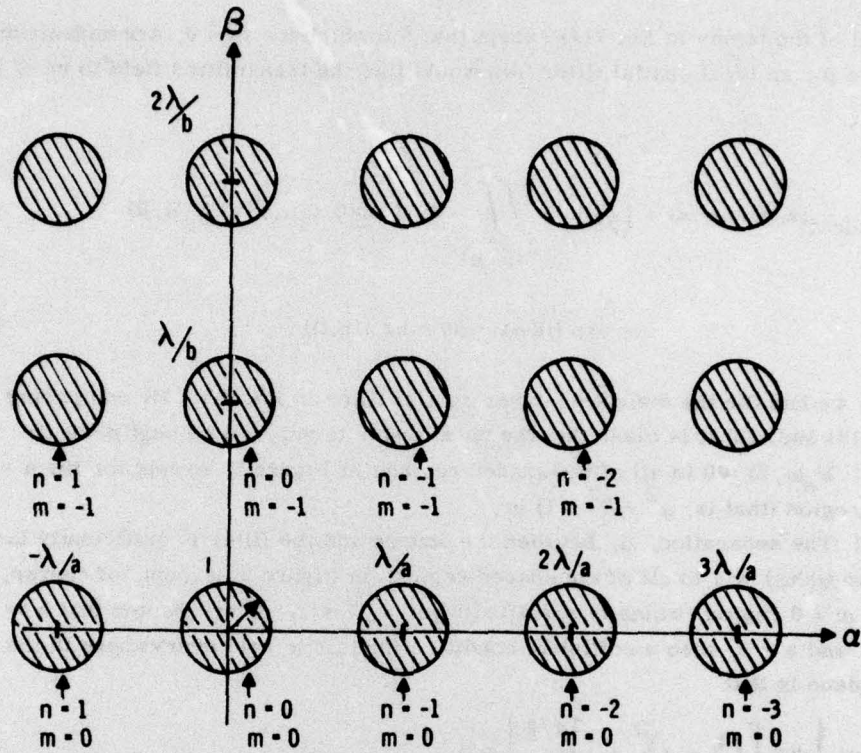


Figure 3. Alpha-Beta Space

$$\underline{E}(x, y, z \rightarrow \infty) = \left(\frac{1}{2\pi}\right)^2 \sum_{n, m=-\infty}^{\infty} \iint_{\substack{(n, m) \\ \text{shaded} \\ \text{region}}} d\alpha d\beta \underline{Q}(n, m, \alpha, \beta) \cdot \hat{\underline{E}}_0(\alpha, \beta) \cdot \exp \left[ ik \left( \alpha + \frac{2\pi m}{ka} \right) x + ik \left( \beta + \frac{2\pi m}{kb} \right) y + ik(\gamma_{nm} z + h\Delta) \right] , \quad (14)$$

where each integral is only over the appropriate shaded region denoted by  $(n, m)$  in Figure 3. That is, when  $n = 1$  and  $m = 0$  the integration is only over the  $n = 1$ ,  $m = 0$  circle shown as shaded in Figure 3.



All of the terms in Eq. (14) except that for which  $n = m = 0$ , are undesirable because for an ideal spatial filter, we would like the transmitted field to be of the form\*

$$E_{\text{ideal}}(x, y, z \rightarrow \infty) = \left(\frac{1}{2\pi}\right)^2 \iint_{\alpha^2 + \beta^2 \leq 1} d\alpha d\beta Q(0, 0, \alpha, \beta) \cdot \hat{E}_0(\alpha, \beta) \cdot \exp[ik(\alpha x + \beta y + hz + h\Delta)] , \quad (15)$$

just as we had for the dielectric-layer spatial filter in Eq. (7). By comparing Eqs. (14) and (15) it is clear that the undesirable terms will be negligible if:

(1)  $\hat{E}_0(\alpha, \beta) = 0$  in all of the shaded regions in Figure 3, except for the  $n = 0$ ,  $m = 0$  region (that is,  $\alpha^2 + \beta^2 \leq 1$ ) or,

(2) The separation,  $\Delta$ , between the source and the filter is sufficiently large that  $\exp(ikh\Delta) \ll 1$  in all of the shaded regions in Figure 3, except, of course, the  $n = 0$ ,  $m = 0$  region, which is specified by  $\alpha^2 + \beta^2 \leq 1$ . If we assume that  $\lambda \gg a$ ,  $\lambda \gg b$ , and  $a \geq b$ , then a sufficient condition for this to hold everywhere in the  $(\alpha, \beta)$  plane is that

$$\exp \left\{ -k\Delta \left[ \left( \frac{\lambda}{a} - 1 \right)^2 - 1 \right]^{1/2} \right\} \ll 1 \quad (16)$$

which leads to the requirement that

$$\Delta \gg \frac{a}{2\pi} \left[ 1 - \frac{2a}{\lambda} \right]^{-1/2} . \quad (17)$$

When Eq. (17) holds we can be assured, except for pathological cases, that the unwanted terms are unimportant, even when  $\hat{E}_0(\alpha, \beta)$  is non-zero in some of the shaded regions in  $\alpha - \beta$  space in Figure 3. As an example of the practical meaning of Eq. (17), let us suppose that  $a = 0.1\lambda$ . Then Eq. (17) requires that  $\Delta \gg 0.018\lambda$ , a condition which is generally quite easy to satisfy. Therefore, if we are interested only in the far fields, it doesn't matter where we place the wire-grid spatial filter relative to the antenna, so long as the separation is such that Eq. (17) is satisfied.

\*Note that  $\gamma_{00} = h$



## 5. DISCUSSION

We have demonstrated that, if one assumes the original source distribution is unaltered by the presence of the spatial filter, the filtering properties of either infinite, planar dielectric layers or infinite, planar wire grids are the same whether we place the filter near to the source antenna or far from it. That is, the far field of an antenna with a dielectric-layer filter (which is infinite and homogeneous in the x-y direction) or a wire-grid filter in front of it, is independent\* of the separation between the antenna and the filter. Of course, in practice, we cannot place the filter arbitrarily close to the source, because then our assumption that the source distribution is unaffected by the presence of the spatial filter, is no longer valid. It is probably necessary to have at least a  $\lambda/4$  separation between the antenna and filter in order to avoid any significant distortion of the original current distribution on the source.

---

\* Provided Eq. (17) holds, for the case of the wire grid.

## References

1. Mailloux, R. (1976) Synthesis of spatial filters with Chebyshev characteristics, IEEE Trans. Ant. and Prop. AP-24:174-181.
2. Fante, R., and Mayhan, J. (1970) Bounds on the electric field outside a radiating system, IEEE Trans. Ant. and Prop. AP-18:64-68.
3. Stratton, J. (1941) Electromagnetic Theory, Chapter 9, McGraw-Hill, New York.
4. Hill, D., and Wait, J. (1976) Electromagnetic scattering of an arbitrary plane wave by a wire mesh with bonded junctions, Canadian J. Phys. 54:353-361.